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Lubrication

A Technical Publication Devoted to the Selection and Use of Lubricants

THIS ISSUE

Service Experience in Controlling Low Temperature Engine Deposits

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FUELS AND ENGINEERING SERVICE

LUBRICATION

A TECHNICAL PUBLICATION DEVOTED TO THE SELECTION AND USE OF LUBRICANTS

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Service Experience in Controlling Low Temperature Engine Deposits

THE November, 1945 issue of LUBRICATION discussed a laboratory engine test which had been developed to simulate low temperature service conditions and which was employed in a comprehensive study of the factors affecting low temperature engine deposits. With the establishment of those factors principally involved in the formation of these deposits, field tests have been and are being conducted to determine the effectiveness of these pertinent variables under service conditions. It is the purpose of this article to present the results of some of these tests.

CITY BUS SERVICE

A large bus fleet operating in an eastern metropolitan was troubled with sludge deposits attributable primarily to operating conditions and mechanical design. During the winter period, when atmospheric temperatures dropped to freezing, the engines of those busses parked outdoors were idled at a moderate speed for extended periods to prevent freezing of the water in the cooling systems and to eliminate hard starting. Operating under these conditions a typical low temperature type of deposit was formed which was subsequently rendered more tenacious by the higher engine temperatures which prevailed during daytime service conditions. In the alleviation of these deposits the effect of jacket temperature control, oil drain period and crankcase ventilation were investigated; the results are discussed below.

Engines

Two popular makes of busses were involved, one powered with a 12-cyl., pancake type L-head engine (Engine A), the other with a 6-cyl., upright valve-in-head engine (Engine B). New or newly overhauled engines or engines with low mileage were used. The latter were inspected and their condition noted before being placed on test. All engines were operated on a 2-104B type oil, SAE 40 viscosity, and premium grade gasoline. The test was conducted during the period November, 1945 to May, 1946 and the test busses operated from 7,600 to 18,000 miles under the various types of service normally encountered. This included intermittent engine idling outdoors at night as discussed previously.

Effect of Jacket Temperature Control

Inspection of the standard thermostats in Engine A revealed unsatisfactory operation in most in-

The first article of this series appeared in the December, 1944 issue of LUBRICATION under the title of "Low Temperature Sludge in Automotive Gasoline Engines."

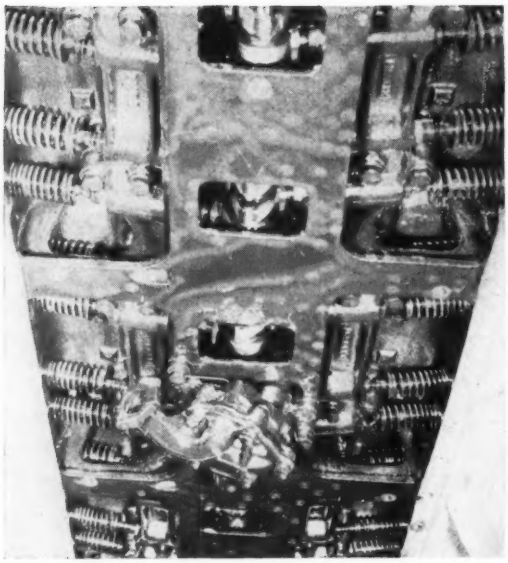


Figure 1—Typical, clean condition of valve chamber in Engine A after 10,770 miles with improved jacket temperature control.

stances resulting in low jacket temperatures. A double acting air operated valve controlled by the aquastat operating the radiator shutters was devised to replace these standard thermostats and a rapid rate of warm-up with adequate jacket temperature control was effected thereby. Two busses were equipped with this device for test purposes. Figure 1 shows the typical, clean-engine condition resulting from improved jacket temperature control on this engine.

Temperature control on Engine B was obtained by means of an aquastat which actuates air-operated shutters controlling air flow to the radiator. With properly adjusted aquastats all operating temperatures proved to be adequately high.

With jacket temperatures of approximately 175°F. effected in both engine types, oil and intake mixture temperatures fell into the preferred range of 180-210°F. and 140-160°F. respectively.

Effect of Oil Drain Period

When it was found that proper jacket coolant temperature control would maintain all other operating temperatures in the preferred ranges, four busses powered with Engine A were placed on each of 500, 1500 and 3000 mile oil and filter element changes. Typical engine conditions for the various oil and filter element change periods are shown in Figs. 2, 3 and 4. From the inspections made, it appeared that with increasing lengths of service between oil and filter changes, engine deposits also increased. It is significant that this performance is in agreement with laboratory engine tests.

Effect of Crankcase Ventilation

Since laboratory engine tests showed a tendency to form less low temperature sludge with increased crankcase ventilation and proper direction of ventilating air flow, tests were made to study these effects.

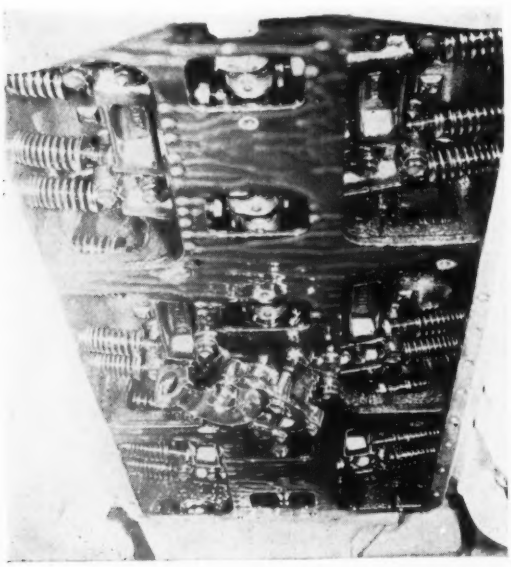


Figure 2—Typical condition of valve chamber in Engine A after 11,747 miles of service on 500 mile oil drain and filter change schedule.

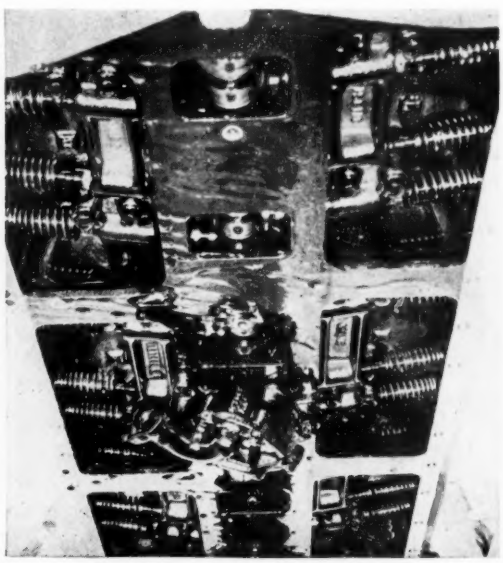


Figure 3—Typical condition of valve chamber in Engine A after 14,847 miles of service on 1500 mile oil drain and filter change schedule.

Standard crankcase ventilation of Engine A is accomplished by means of a venturi breather pipe exhausting from the front auxiliary drive housing. Fresh air enters through a screen type filter mounted at the center of the top side of the engine. Since crankcase ventilation with this installation depends upon the venturi effect attained at the breather pipe when the bus is in forward motion, it was quite evident that insufficient ventilation was provided during the outdoor idling periods employed in the winter.

Two busses were equipped, therefore, with electric motor driven, Sirocco type fans connected to the engine oil fill pipes so as to exhaust crankcase blow-by vapors. Venturi breather pipes were blocked off while the fresh air inlets were left open. Restriction plates were used on the fans to limit crankcase vacuum to 0.5" water to prevent oil carry-over and suction of contaminants through engine oil seals.

Inspection of the engines at the conclusion of their respective test periods showed no deposits of any kind indicating that increased crankcase ventilation for this particular engine is beneficial in city bus service. A typical engine condition is shown in Fig. 5.

From all indications it appeared that Engine B was troubled primarily with the formation of sludge in the rocker arm chamber and push rod chamber. From laboratory experience, this was an indication that crankcase ventilation might be a part of the cause. Fig. 7, page 16 shows typical sludging conditions in this engine.

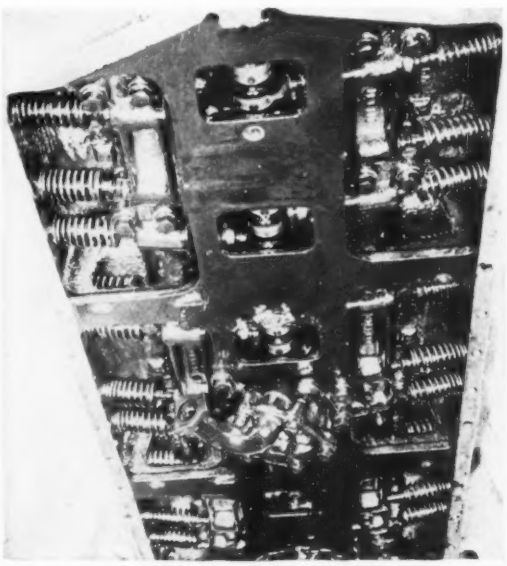


Figure 4—Typical condition of valve chamber in Engine A after 11,088 miles of service on 3000 mile oil drain and filter change schedule.

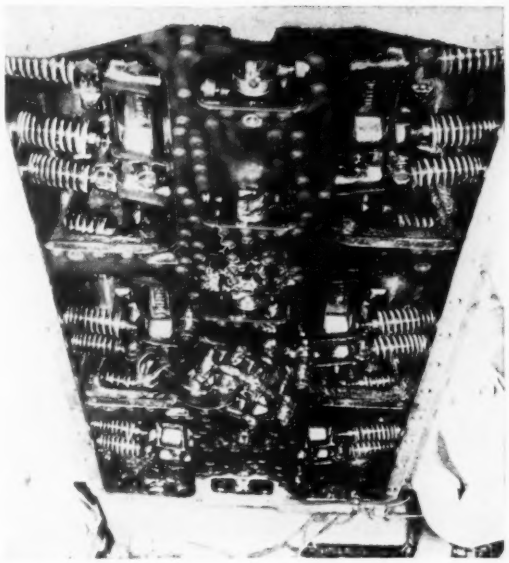
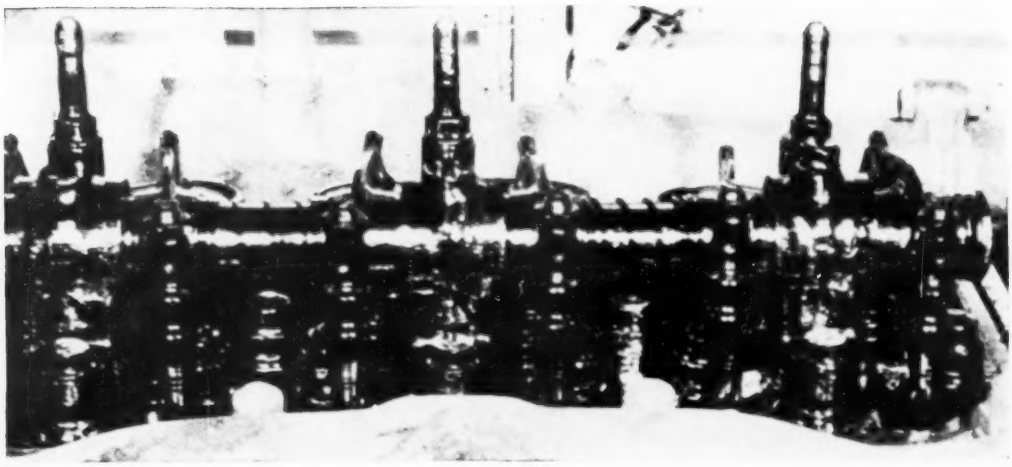


Figure 5—Typical condition of valve chamber in Engine A after 10,163 miles of service with increased crankcase ventilation.

The standard crankcase ventilation system on Engine B consisted of exhausting crankcase vapors upwards through the rocker arm chamber by means of tubing connecting the rocker arm covers to the engine intake air system before the air cleaner. A restriction was placed in this tubing to prevent pulling over oil with the crankcase vapors. Air enters the crankcase through a combination breather air filter and oil fill pipe cap mounted on the push rod cover.

Two of these engines were altered so as to reverse the flow of ventilating air in an effort to remove blow-by contaminants more readily. To accomplish this, the breather-oil fill cap was replaced by a sealing-type cap with a small safety vent. The oil fill pipe was drilled and tapped to take a reduction

Figure 6—Partially clogged portion of suction line in reverse flow crankcase ventilation system on Engine B.



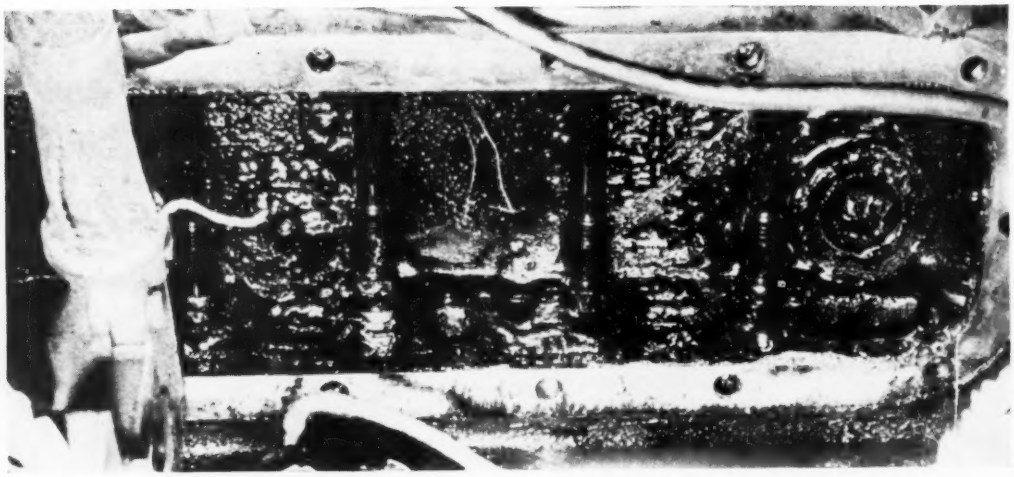
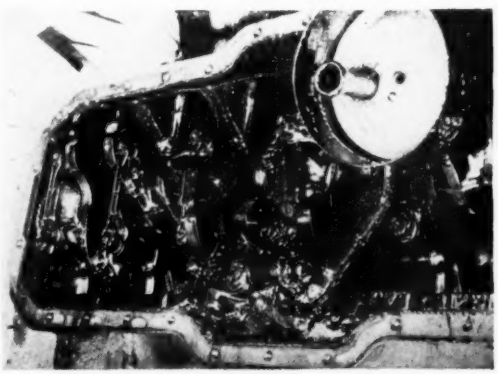


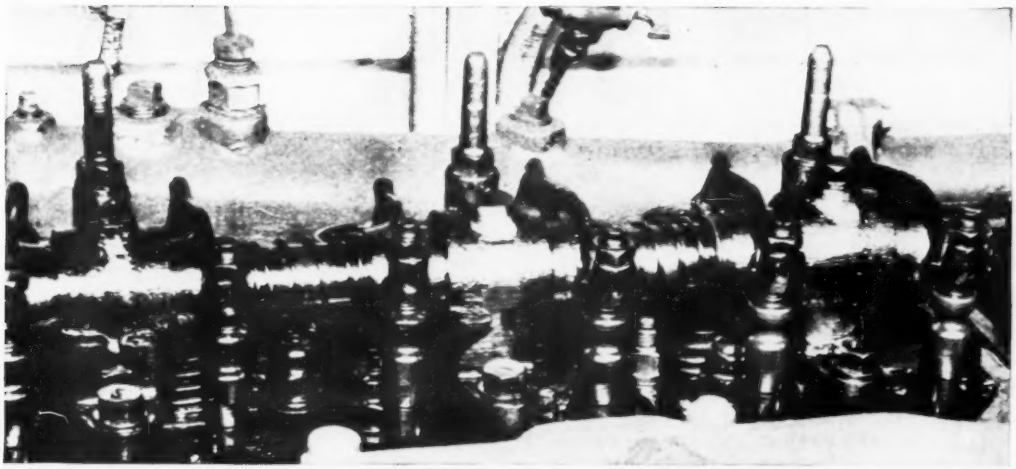
Figure 7—All photographs on this page show typical condition of Engine B after 9,833 miles of service with standard crankcase ventilation.

bushing for ¾" copper tubing that was connected to the engine air intake system before the air cleaner. The restriction of the bushing was sufficient to prevent pulling over of oil with the vapors. The rocker arm chamber was equipped with the normal breather-oil fill cap as a filter and inlet for fresh air.

Inspection of the engines at the conclusion of their respective test periods revealed that with reversed flow crankcase ventilation the formation of engine deposits was greatly reduced when compared with similar engines operating with standard ventilation systems. Engine conditions are shown in Fig. 8, page 17.



It is interesting to note that at the inspection



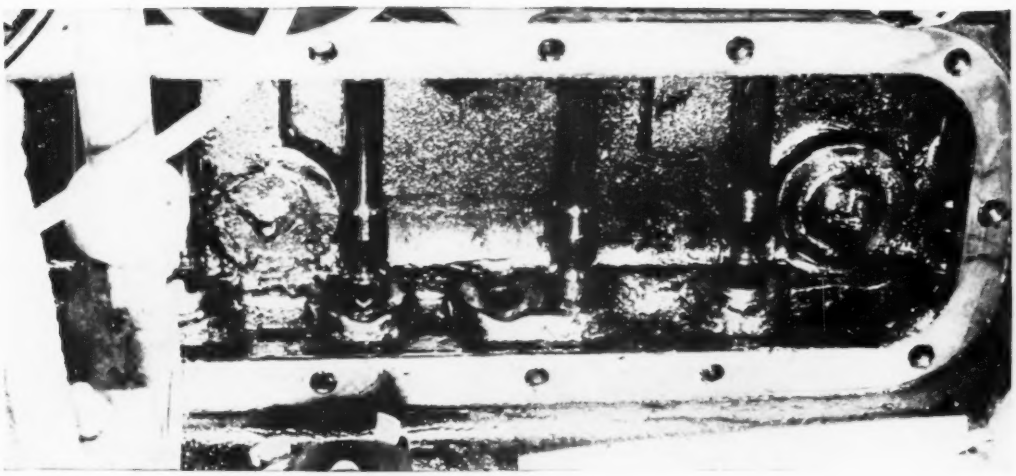
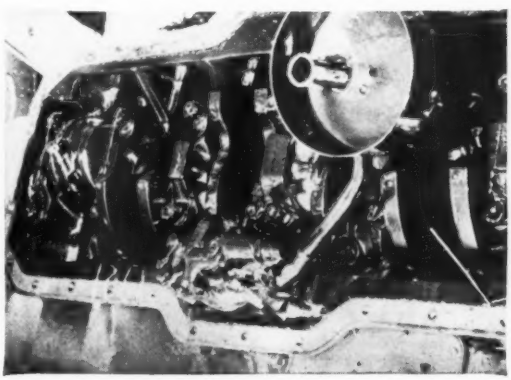


Figure 8—All photographs on this page show typical condition of Engine B after 8,862 miles of service with reversed flow crankcase ventilation.



period, the ventilation suction line of one of the test busses showed signs of clogging. (Fig. 6, p. 15.) This condition indicated that contaminants were being removed and that ventilation systems should be cleaned at regular intervals to maintain them in an operative and effective condition.

DELIVERY TRUCK SERVICE

The effect of jacket temperature and fuel composition on low temperature engine deposits were investigated in eight Chevrolet truck engines operating in house-to-house delivery service. Prior to the start of the test the engines in these trucks were

completely cleaned and reconditioned by installing new tin-plated pistons, rings and other necessary new parts. Four of the engines were equipped with 180° F. cooling system thermostats whereas the other four were operated without thermostats. All engines were equipped with waste-packed type oil filters, new elements being installed at the start of the test.

The operation of these trucks generally consisted of driving 20 to 30 miles in the morning before beginning delivery after which approximately 100 to 150 scattered stops of five to ten minutes duration alternated with driving periods of five to ten minutes duration were made before the return trip of 20 to 30 miles at the end of the day. Thus, the operation entailed an appreciable amount of idling as well as road operation. Each truck was operated on test for 9,000 miles before inspection and determination of deposit weights.

The average jacket temperature for the engines without thermostats was 140° F. whereas, that for engines with thermostats was 180° F. Crankcase oil temperatures for the engines equipped with thermostats were correspondingly somewhat higher than for those not equipped with thermostats. From the above, and the fact that the latter part of the test operation occurred during the early summer months, it is apparent that the lower jacket temperatures were actually in the intermediate rather than the low temperature range. It is believed that if all operation had taken place at lower jacket temperatures in the order of 100-120° F. the difference in deposit weights would have been greatly magnified.

A 2-104B type oil, SAE 20 viscosity, was used in all engines throughout the test. Two of the engines equipped with thermostats and two without thermostats were operated on Fuel A, a blended gasoline, while two engines with and two without thermostats were operated on Fuel B, a straight-run gasoline thus providing duplicate tests for each set of conditions.

Table I, shows the average numerical ratings for each pair of engines operated on each fuel at both high and low jacket temperatures. For comparison the results of laboratory low temperature engine tests* on each fuel are also shown. These numerical ratings are based on actual deposit weights on pistons, oil rings, crank pan and covers. A scale similar to that used in the CRC FL-2 test procedure was employed with a rating of 10 being assigned to a clean part and 0 to a part with the heaviest deposit.

*Coordinating Research Council Designation FL-2, "Test Procedure for Determining Deposits Formed During Low-Temperature Operation."

TABLE I

NUMERICAL RATINGS OF ENGINE DEPOSITS

Fuel	*Jacket Temp.*	*Numerical Rating* (10-Cleanest — 0-Dirtiest)
	Service Tests	
A	High	3.6
A	Low	2.1
B	High	6.8
B	Low	5.9
	Laboratory Tests	
A	Low	2.4
B	Low	5.1

From these data and the photographs, Figures 9, 10, 11, 12, 13, and 14, pages 19, 20, 21, 22, 23 and 24 respectively, showing typical engine conditions, the following are apparent:

1. Fuel A produced heavier deposits than Fuel B under both laboratory and field service test conditions.

2. Fuel A produced heavier deposits in the engines operating at low jacket temperatures than at high jacket temperatures under service conditions.

3. Although Fuel B produced slightly less deposits at high jacket temperatures than at low jacket temperatures under service conditions, the difference was not as pronounced as for Fuel A. This was to be expected since Fuel B produced practically a clean engine under the low temperature operating conditions of the laboratory test.

4. Results of this field service test were in general agreement with those obtained in the laboratory low temperature tests.

CONCLUSION

It is conceivable that in the near future, low temperature engine deposits will have been conquered as completely as high temperature engine deposits. Once again the petroleum industry is cooperating with engine manufacturers and fleet operators in attacking a problem and arriving at the solution. Ever continuing research on petroleum products to improve their performance characteristics has been expanded to include studies at low engine operating temperatures. Engine manufacturers are giving even greater attention to those factors in engine design which affect the formation of these deposits. Last but far from least, fleet operators are cooperating by employing proper maintenance schedules and controlling the mechanical and operating variables involved in the formation of engine deposits.

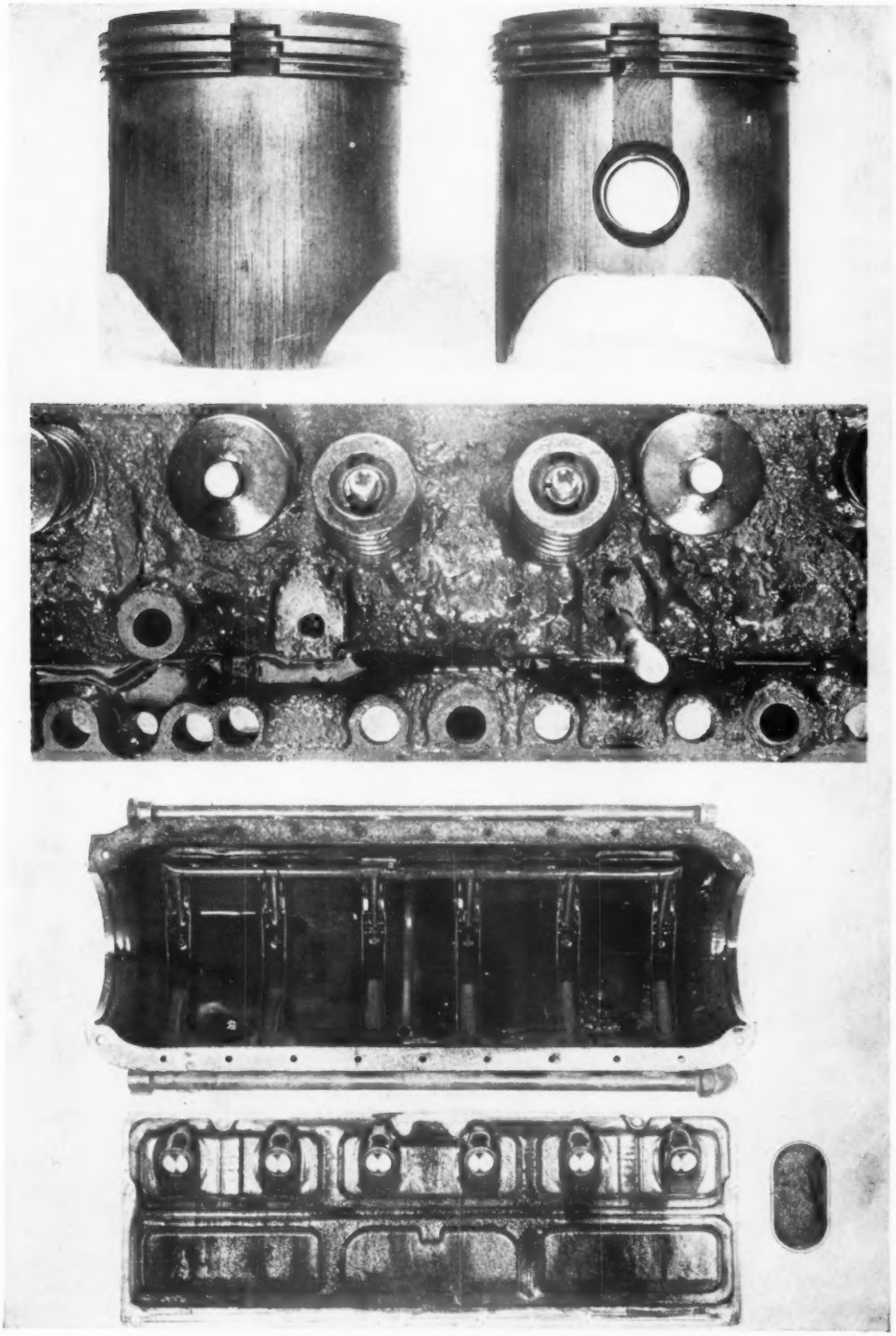


Figure 9—Typical engine condition after laboratory low temperature test (FL-2) on Fuel A.

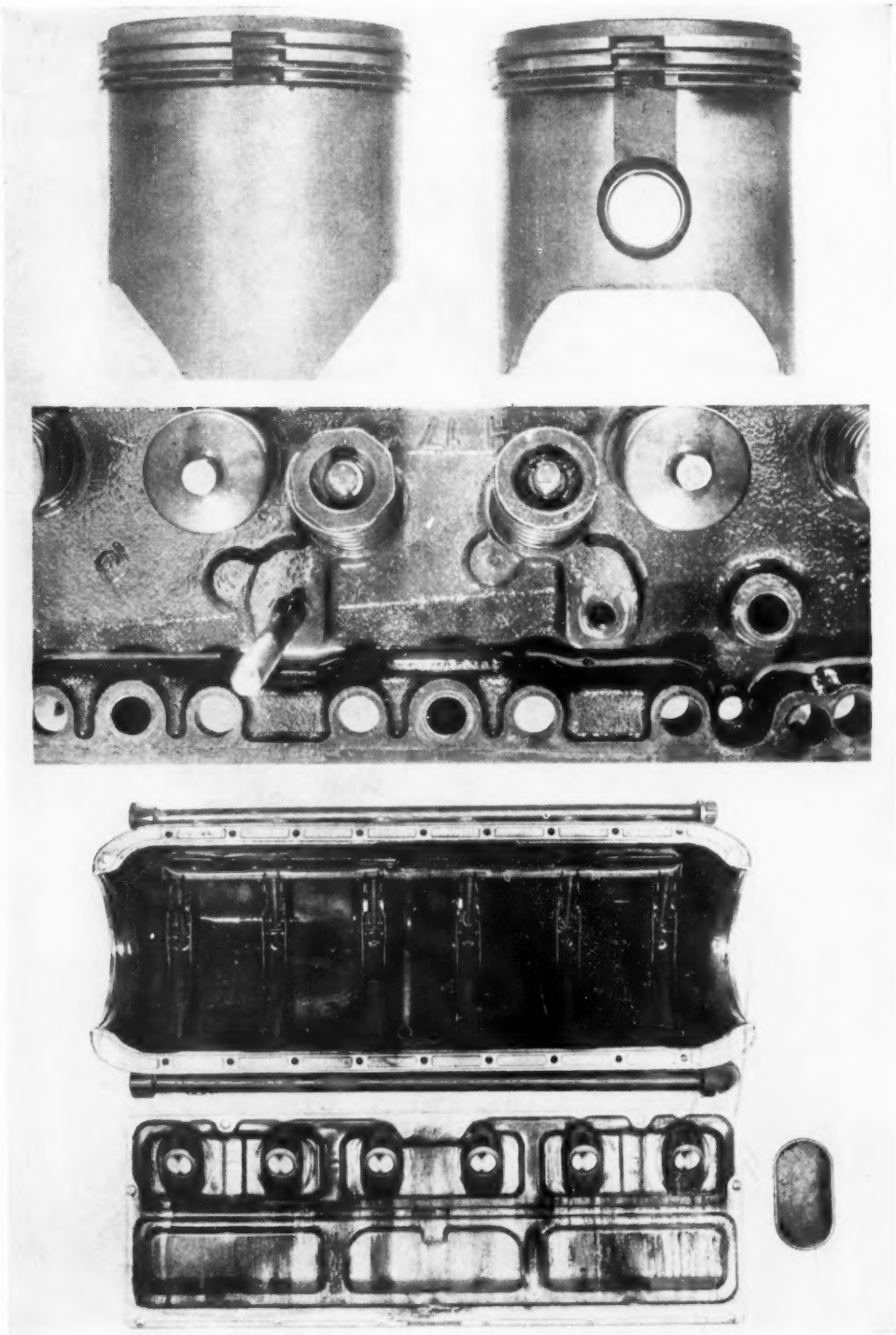


Figure 10—Typical engine condition after laboratory low temperature test (FL-2) on Fuel B.

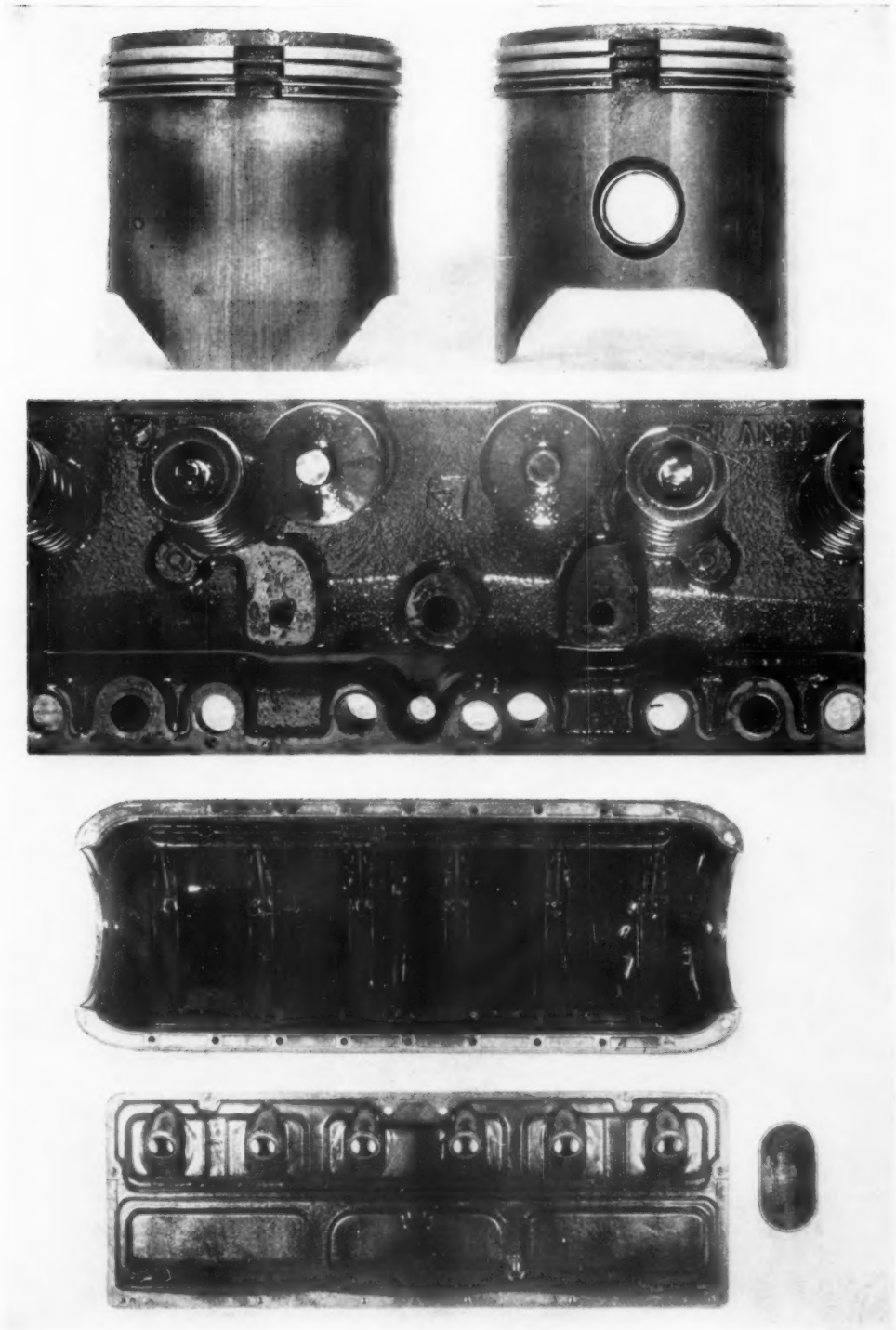


Figure 11—Typical engine condition after field service test on Fuel A at low jacket temperature.

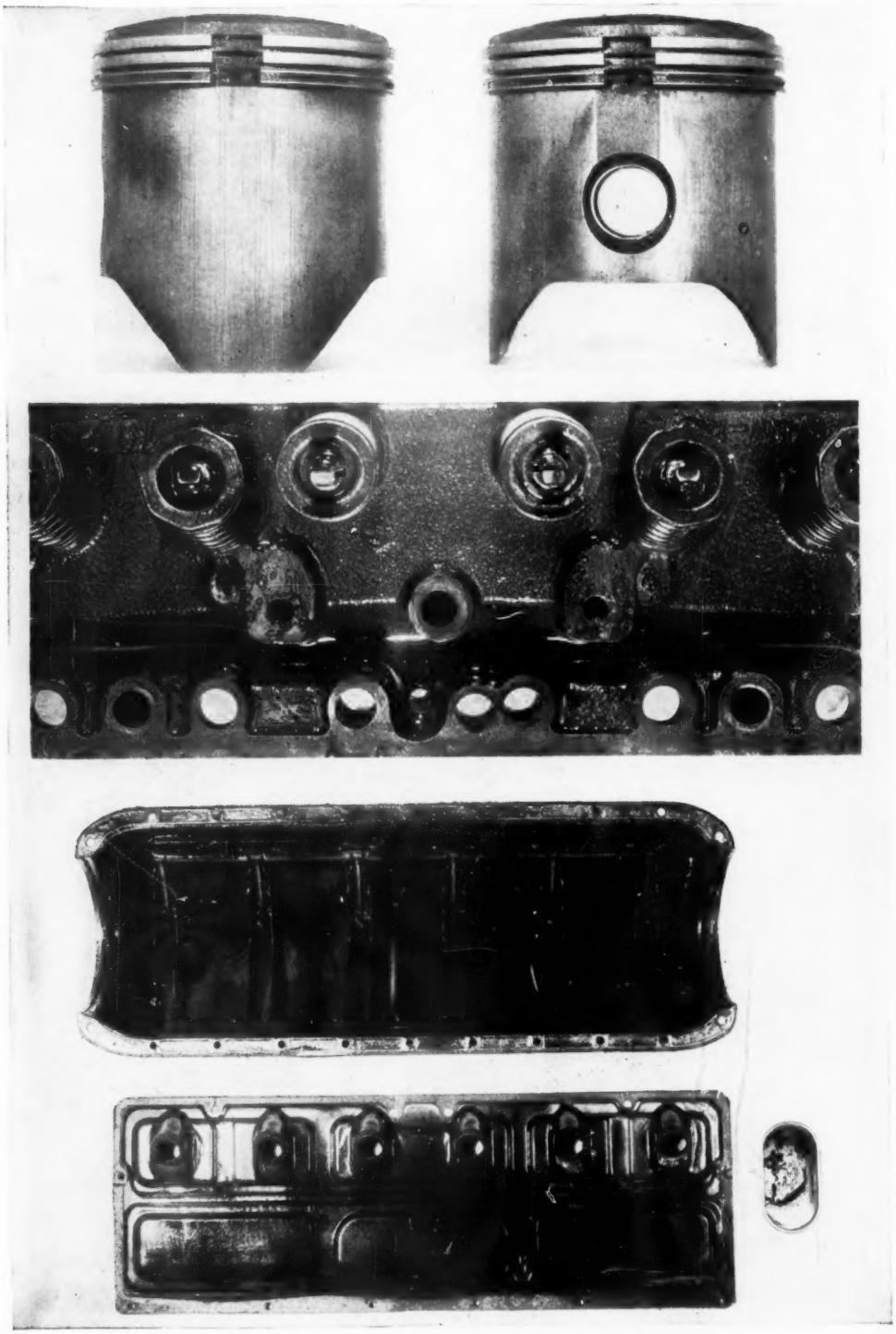


Figure 12—Typical engine condition after field service test on Fuel A at high jacket temperature.

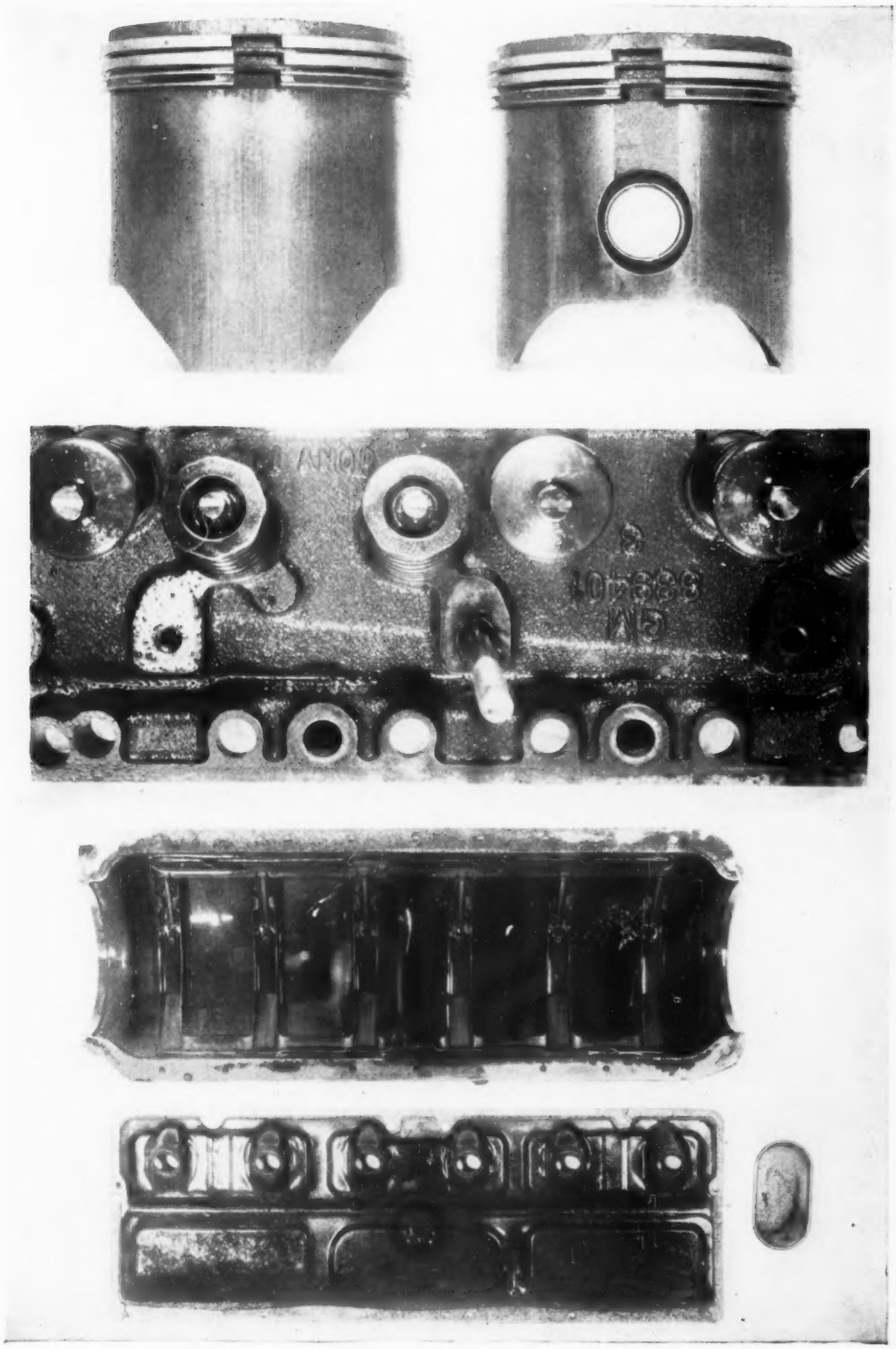


Figure 13—Typical engine condition after field service test on Fuel B at low jacket temperature.

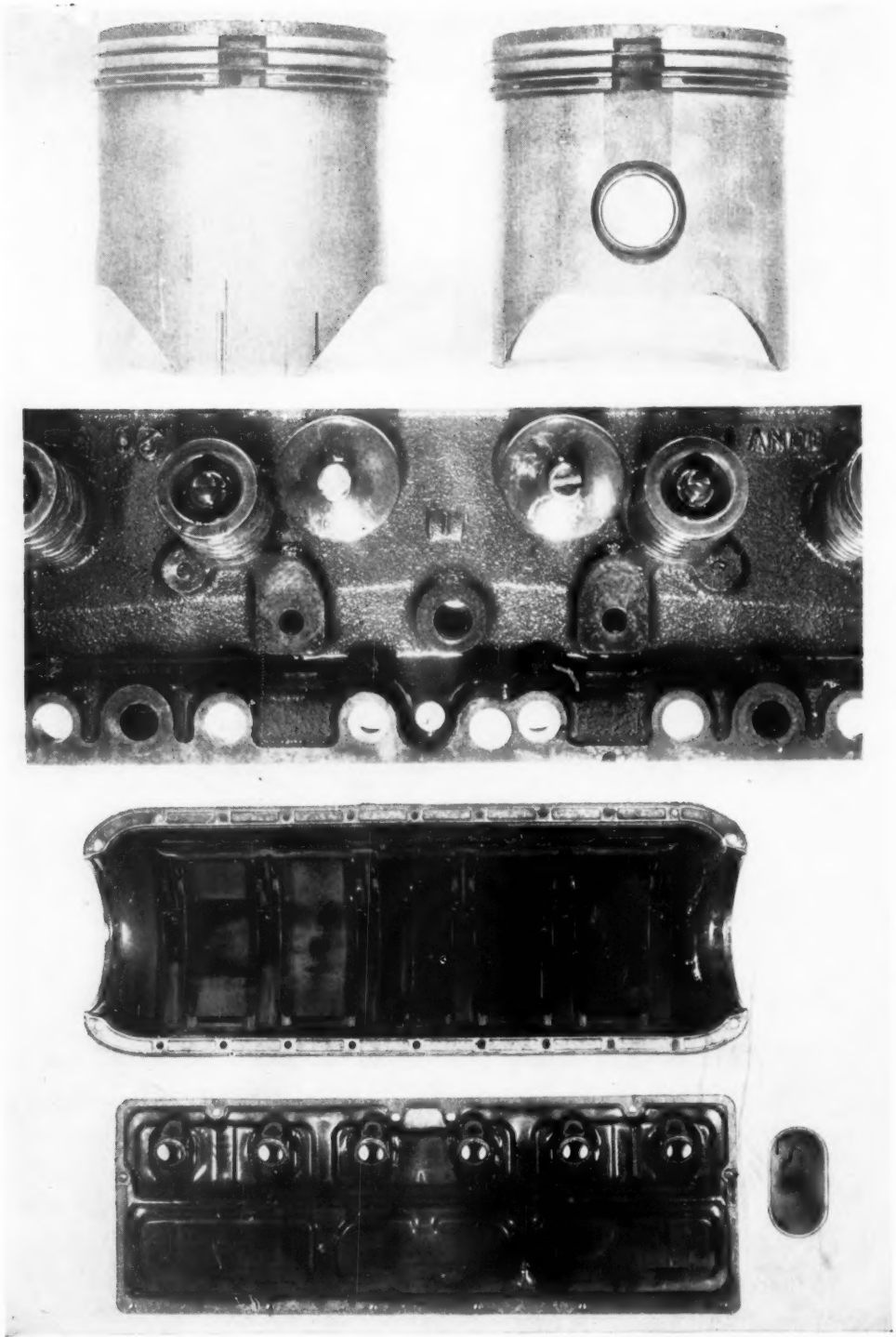


Figure 14—Typical engine condition after field service test on Fuel B at high jacket temperature.

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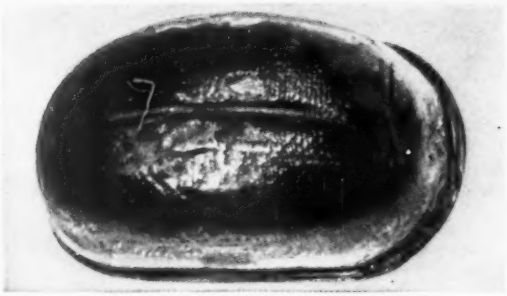

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3. Maintain crankcase oil temperature at approximately 180° F.
4. Keep intake manifold temperature as high as possible consistent with freedom from intake manifold deposits.
5. Change oil as frequently as possible consistent with allowable costs and maintenance schedules. Oil drains should be made while oil is hot after operation.
6. Employ best carburetor and air filter maintenance practices.
7. Use oil filter of adequate capacity and replace element at frequent intervals.
8. Keep crankcase ventilation system clean, in operable condition and as warm as possible to alleviate stoppage due to ice formation.
9. Refrain from idling engine as much as possible particularly during cold weather.

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